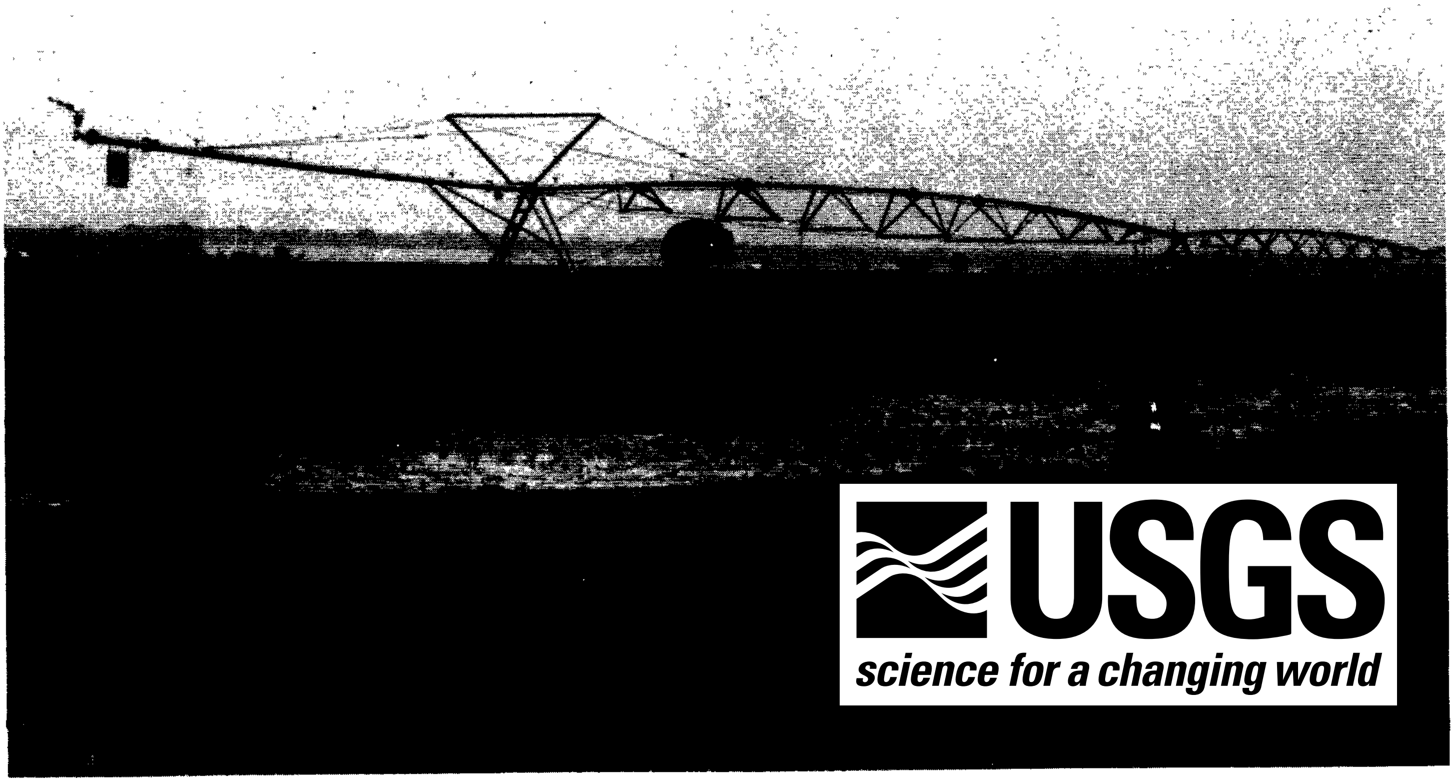
Water Resources Investigations Report 90-4064

RECONNAISSANCE OF THE OCCURRENCE OF AGRICULTURAL CHEMICALS IN GROUND WATER IN HAYWOOD, LAKE, OBION, AND SHELBY COUNTIES, TENNESSEE



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U.S. GEOLOGICAL SURVEY

in cooperation with the
TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT,
DIVISION OF WATER POLLUTION CONTROL

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By Dorothea Withington Hanchar

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric units
acre	0.004047	square kilometer (km^2)
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	0.0038	cubic meter per minute (m^3/min)
pound (lb)	0.4536	kilogram (kg)
pound per acre (lb/acre)	1.120	kilogram per hectare (kg/ha)
square mile (mi^2)	2.590	square kilometer (km^2)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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RECONNAISSANCE OF THE OCCURRENCE OF AGRICULTURAL CHEMICALS IN GROUND-WATER IN HAYWOOD, LAKE, OBION, AND SHELBY COUNTIES, TENNESSEE

By Dorothea Withington Hanchar

ABSTRACT

Data on the occurrence of agricultural chemicals in ground water in Tennessee are sparse. The surficial alluvial aquifer is an important source of domestic water supply in West Tennessee, and potentially is subject to contamination from the application of agricultural chemicals in the area. Nineteen shallow wells completed in the alluvial aquifers in areas of high density agricultural use were sampled in the winter and again in the summer of 1988 to ascertain the occurrence of agricultural chemicals in ground water. Although no triazine herbicides or organophosphorus insecticides were detected in any of the wells sampled, elevated nitrite plus nitrate (as nitrogen) concentrations were detected. Results from the winter sampling period indicate a range of nitrite plus nitrate (as nitrogen) concentrations of less than 0.1 to 7.8 milligrams per liter with a median concentration of 2.6 milligrams per liter. Results from the summer sampling period indicate a range of nitrite plus nitrate (as nitrogen) concentrations of less than 0.1 to 8.9 milligrams per liter, median, 2.5 milligrams per liter. The highest concentrations occurred in the shallowest wells, and, in one instance, in a shallow well near a heavily irrigated field.

INTRODUCTION

Nearly one-half of Tennessee's total land area is devoted to farming (Tennessee Agricultural Statistics Service, 1987, 1988). Large-scale agricultural operations are common in West Tennessee, an area which is noted for extensive row-cropping. For example in Lake County, located in the northwestern corner of the State, 81 percent of the land is planted primarily in soybeans and corn (Tennessee Agricultural Statistics Service 1987, 1988). Pesticides and fertilizers are applied to crops throughout these areas to maximize production. In areas of soybean cultivation, 48 percent of harvested acreage is fertilized, and in cotton-producing areas, 100 percent of the cultivated land is fertilized. During the past 40 years

(1946-85), more than 735,000 tons of fertilizer have been applied to Tennessee soil (Tennessee Agricultural Statistics Service, 1987, 1988).

Pesticides used in Tennessee include a variety of herbicides, insecticides, and other chemical agents. In West Tennessee, triazine herbicides are the principal types applied. These herbicides are used on all crop types. In cotton-growing areas, methyl parathion (an organophosphorus insecticide) is also used for the control of boll weevils (*Anthonomus grandis*).

The potential effect of agricultural chemical application on ground water is of concern because the main source of water for domestic supply in rural areas of West Tennessee is ground water. To address this concern, the U.S. Geological Survey (USGS), in cooperation with the Tennessee Department of Health and Environment, Division of Construction Grants and Loans, conducted a reconnaissance of the occurrence of agricultural chemicals in ground water in three high-intensity agricultural areas in West Tennessee to determine the concentrations of these chemicals in the shallow ground water. The areas, in Haywood, Lake and Obion, and Shelby Counties, were selected to represent areas producing the major agricultural products of West Tennessee: soybeans and corn and, in Haywood County, cotton (fig. 1). Haywood County is the largest producer of cotton in Tennessee; corn and soybeans are also produced in the county. Shelby County produces mostly soybeans and cotton, while Lake County is ranked fifth in the State for soybean production (Tennessee Agricultural Statistics Service, 1987, 1988).

Purpose and Scope

The purpose of this investigation was to determine if selected agricultural chemicals occur in the shallow alluvial aquifer at representative sites in agricultural areas in West Tennessee. This report documents the results of analyses of ground-water samples collected at these sites during the period January and February 1988, April 1988, and again in June 1988. The report includes a discussion and interpretation of geochemical data, and documents the results of a simple, nonparametric statistical analysis of the water-quality data.

Previous Investigations

To date, there have been no systematic studies statewide of the occurrence of pesticides and nutrients in ground water. The USGS has, however, published pesticide-concentration data for bottom-material and surface-water samples for some of the streams in Tennessee (Gaydos, 1983; Robbins and others, 1985), and ground-water-quality data including some pesticide data for the water-table aquifer in the Memphis area (Parks and others, 1981; McMaster and Parks, 1988). Investigators with the Tennessee Valley Authority also have published total nitrite plus nitrate concentrations in ground water in selected areas in Tennessee (Soileau, 1988).

Acknowledgments

The author expresses her appreciation to the many landowners who provided access to their wells. Also, thanks are due William Gordon, Agricultural Extension Service; William Daniels, Farm Manager, Agricenter International; Calvin Prince, Farm Manager, Shelby County Penal farm; and the many farmers who provided information on chemical applications.

PHYSIOGRAPHIC AND GEOLOGIC SETTING

The three study areas are situated in two major physiographic subdivisions (fig. 1). Two of the areas, one in Shelby County and the other in Lake and Obion Counties, lie in the Mississippi

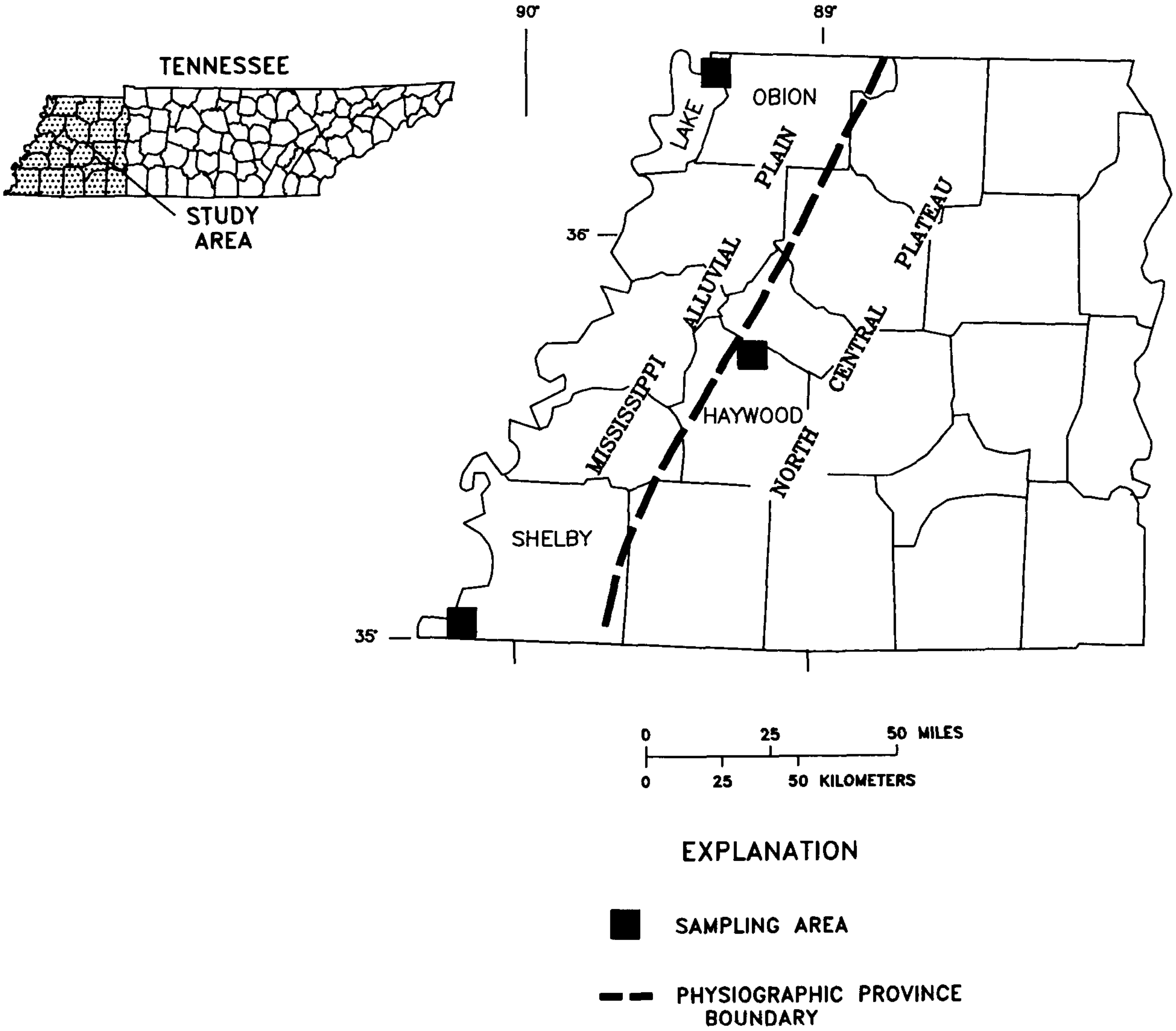

Figure 1.--Location of the three sampling areas in West Tennessee.

River Alluvial Plain of the Coastal Plain physiographic province. The third area, in Haywood County, is located predominantly in the Gulf Coastal Plain of the Coastal Plain province (Fenneman, 1938). The shallow water-table aquifer consists of alluvial and terrace deposits, and, in Haywood County, loess deposits.

The alluvium and terrace deposits consist of unconsolidated sand, gravel, silt, and clay. In the area examined in Shelby County, these deposits are composed of 50 feet of Wolf River alluvial material, while in Lake and Obion Counties, the shallow water-table aquifer consists of greater than 100 feet of Mississippi River alluvial deposits.

Table 1.—*Amount of irrigated land and ground-water withdrawals for irrigation in Haywood, Lake, and Shelby Counties, 1986*

[Source: Hutson, 1988]

County	Irrigated land, in percent	Irrigated land, in thousand acres	Withdrawals, in million gallons per day
Haywood	1.0	1.45	0.17
Lake	3.6	2.71	.09
Shelby	1.4	1.37	.03

LAND USE AND CHEMICAL APPLICATION

Land in West Tennessee is among the most intensively cultivated in the State. In Haywood County, 80,000 acres are used for the production of cotton, while in Lake County, 61,000 acres are used to grow soybeans (Tennessee Agricultural Statistics Service, 1988).

Irrigated cropland accounts for less than 1 percent of cultivated land, although use of irrigation has increased 50 percent since 1980 (Hutson, 1988). The limited irrigation in the areas examined is predominantly from ground-water sources (Hutson, 1988). Irrigation data for the counties containing the three study areas are summarized in table 1. In this study, one well sampled (Ha:L-002) was located near two irrigation pivots. During 1986, the irrigation system was operated on three occasions for a total of 336 hours, pumping at an average rate of 1,300 gal/min (S. Hutson, U.S. Geological Survey, written commun., 1988).

Rainfall can contribute to the chemical load in ground water. According to the National Weather Service (National Oceanic and Atmospheric Administration, 1988), 1988 was a year of extreme drought, and rainfall at all three areas was well below average. Rainfall summaries for three stations within the area of concern are presented in table 2. Although rainfall can be another source of nitrate and other nutrients, the contribution from this source during this study was probably negligible due to these dry conditions.

Current (1989) soybean and cotton production techniques usually require some applications of fertilizers containing nitrogen. Total nitrogen-application rates of 75 lb/acre for cotton and 20 lb/acre for soybeans are commonly used in Tennessee (Tennessee Agricultural Statistics Service, 1988). Total nitrogen is applied mostly in the form of anhydrous ammonia (NH_3). Nitrate, which is produced by the denitrification of ammonia, is water soluble and very mobile. Under oxidizing conditions in shallow aquifers, nitrate can be carried into the saturated part of the aquifer and can migrate downgradient from application areas. Another source of nitrate in ground water is septic systems.

Evaluation of existing data of nitrate concentrations in the United States defines concentrations of greater than 3 milligrams per liter (mg/L) as indicative of possible human input

Table 2.—*Monthly precipitation, in inches, January through June 1988, for stations located in Haywood, Lake, and Shelby Counties*

[Source: National Oceanic and Atmospheric Administration, Climatological Data, Tennessee, 1988, v. 93, no. 1-6]

Month	Haywood County, Brownsville station	Lake County, Union City station	Shelby County, Memphis station
January	5.26	5.12	4.25
February	4.19	4.14	3.49
March	3.17	3.88	4.20
April	2.93	2.02	2.85
May	3.48	2.50	2.38
June	.01	.43	2.15

(Madison and Brunett, 1985). A preliminary study of nitrate concentration within the Tennessee Valley region shows that less than 5 percent of the wells sampled had concentrations greater than 3 mg/L (Soileau, 1988).

During 1986, an estimated 3,000 tons of pesticides (active ingredients) were applied in Tennessee (L.L. Gianessi and C.A. Puffer, Resources for the Future, written commun., 1988). The triazine herbicides are used with cultivation practices in row crops to control grasses and broadleaf weeds. Application rates for triazine herbicides range from 0.5 to 3 lb/acre. Application rates for organophosphorus insecticides range from 0.19 to 3 lb/acre (William Gordon, Tennessee Agricultural Extension Service, written commun., 1988). Organophosphorus insecticides are used in Tennessee primarily for the control of boll weevils in cotton production areas. Data summarizing all pesticides used in the counties studied are presented in table 3 (L.L. Gianessi and C.A. Puffer, Resources for the Future, written commun., 1988). Table 4 lists pesticides applied in the study area during the 1988 growing season.

COLLECTION OF HYDROLOGIC DATA

The wells sampled in each area were completed in the shallow ground-water system. The shallow water-table aquifer was selected for this study because it is the aquifer most likely to contain agricultural chemicals. The wells sampled in Lake County are unused domestic wells. In Haywood County, the wells are active domestic wells. The wells sampled in Shelby County were constructed in an agricultural setting as part of another study. The wells in Shelby and Lake Counties are located in fields away from other development. The sampling areas in Shelby and Lake Counties were selected because of ongoing hydrogeologic investigations by the USGS and because of the availability of existing wells and well construction information. All wells sampled were in or near fields under active cultivation. A total of 20 wells were sampled for this study; 7 wells in Haywood County, 6 wells in Lake County, 1 well in Obion County near Reelfoot Lake, and 6 wells in Shelby County (figs. 2-4). The Shelby County wells are located on the Agricenter International and the Shelby County Penal Farm

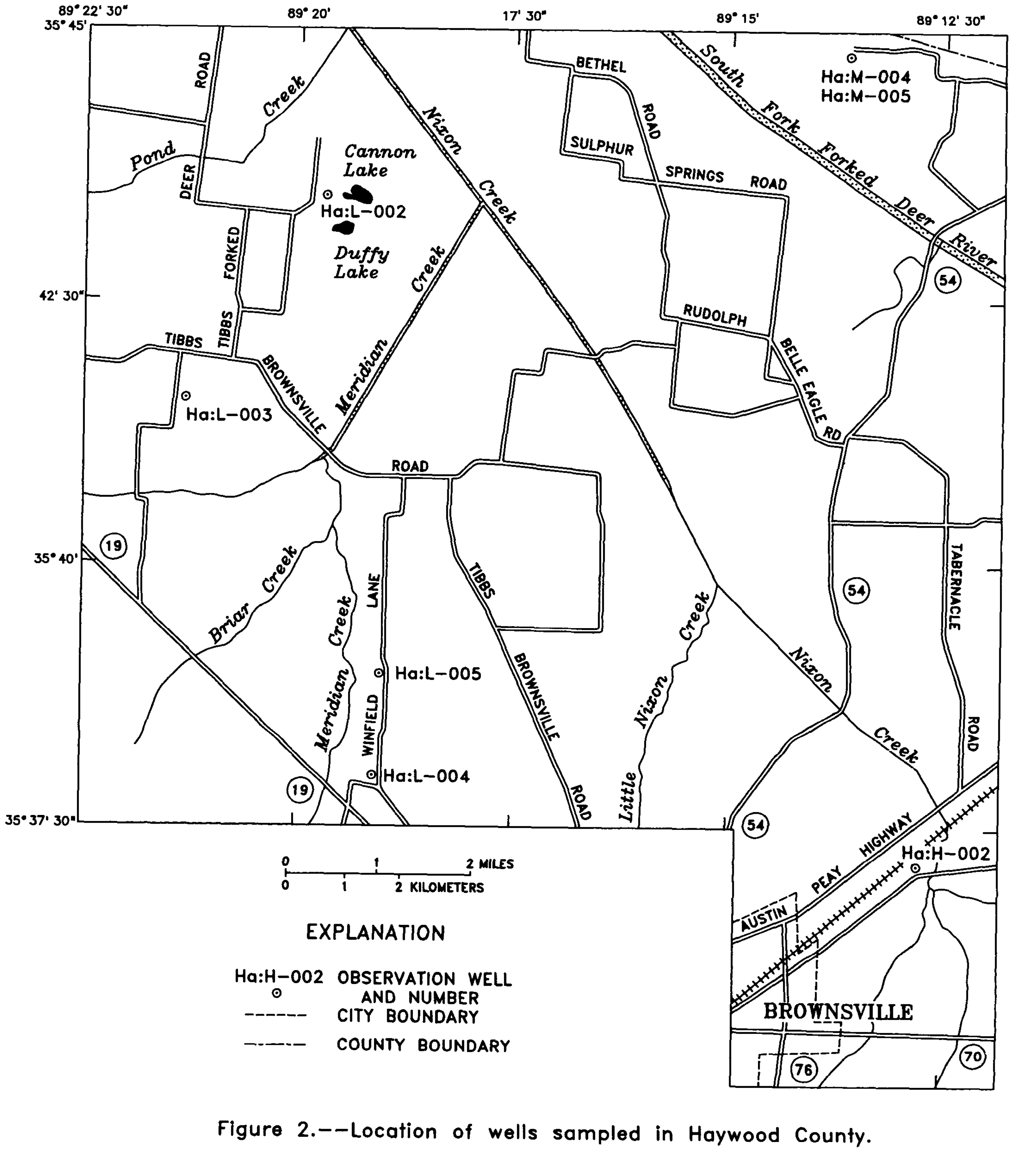

Figure 2.--Location of wells sampled in Haywood County.

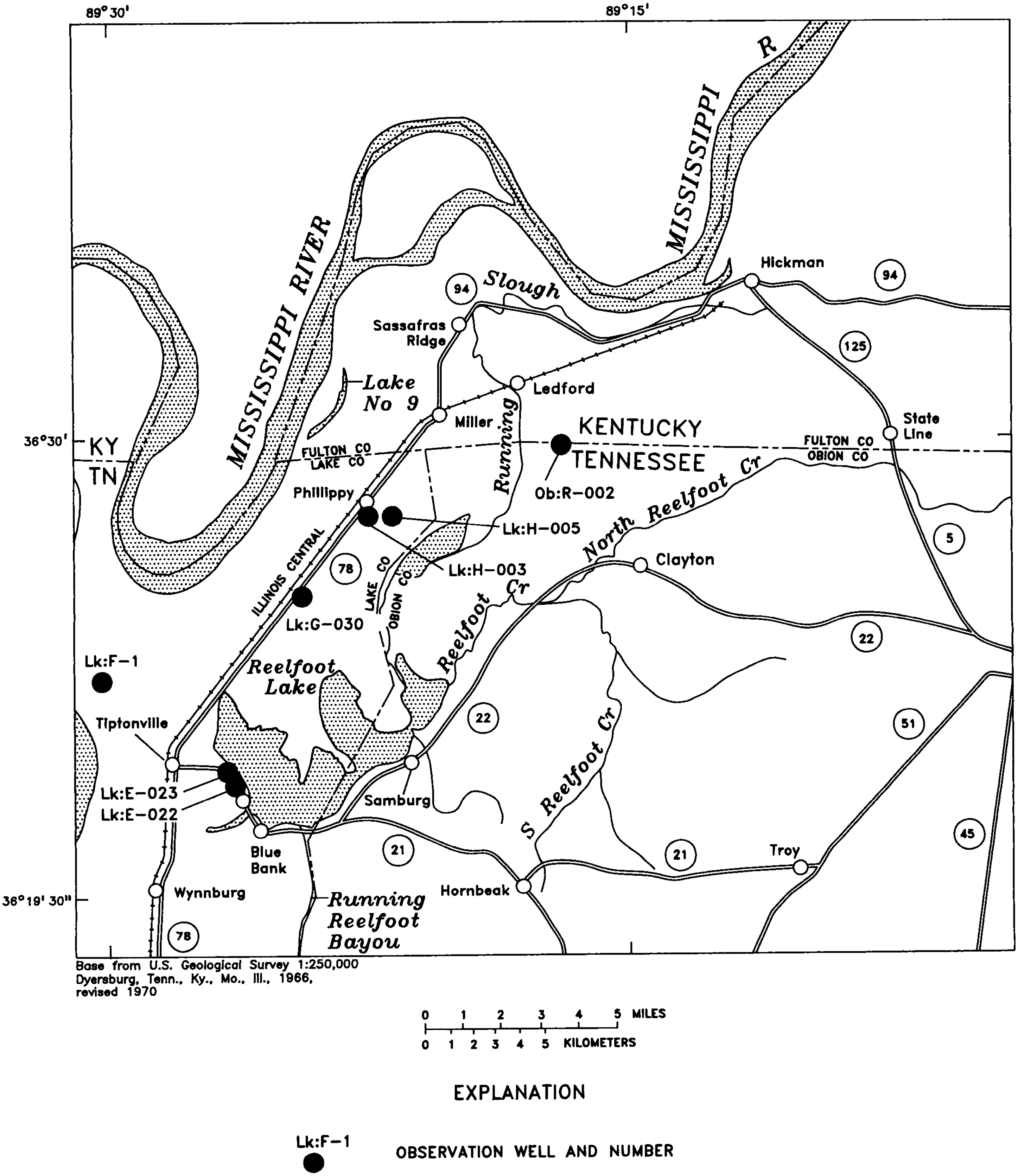

Figure 3.--Location of wells sampled in Lake and Obion Counties.

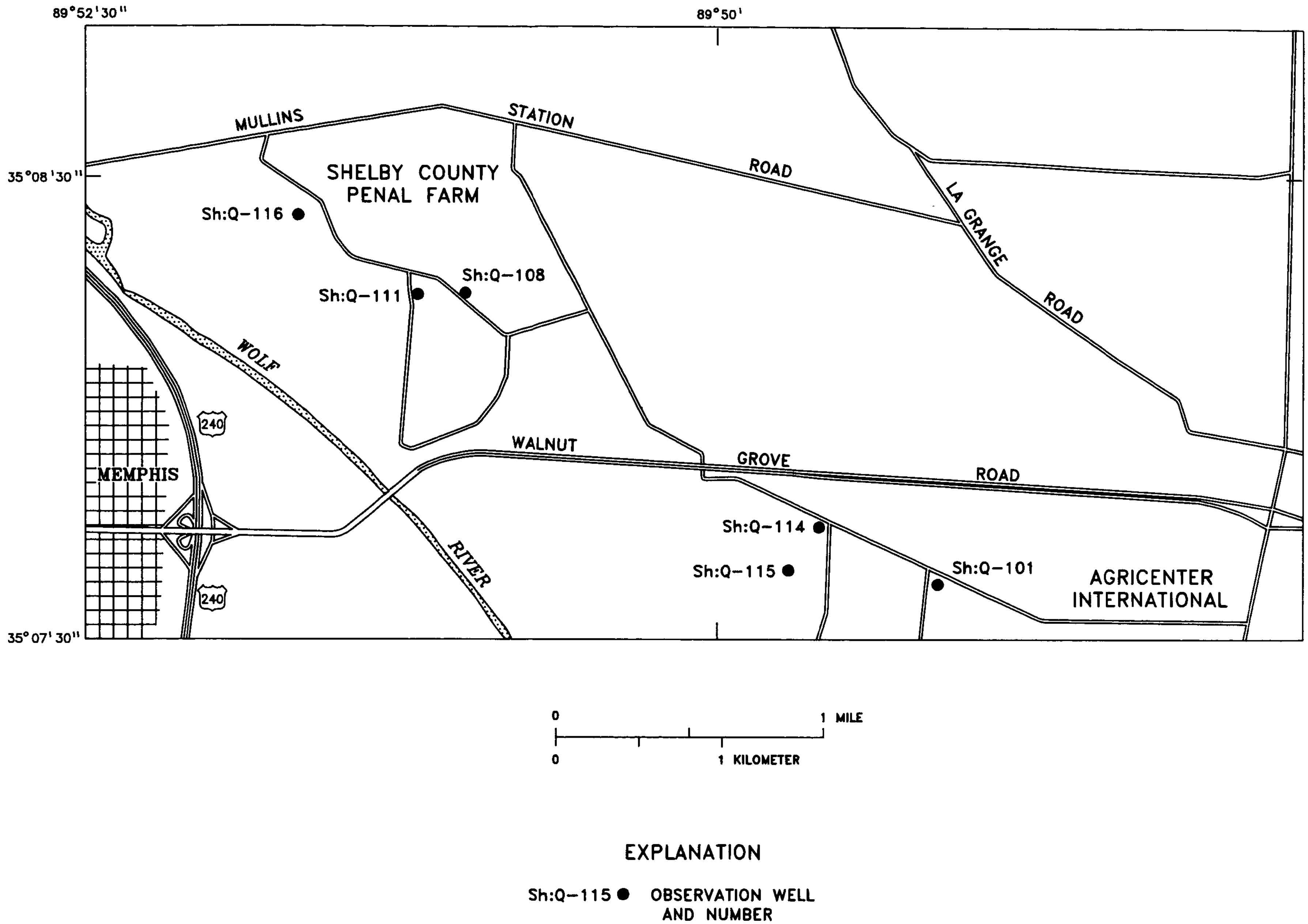

Figure 4.--Location of wells sampled in Shelby County.

Table 3.—*Acres treated with selected pesticides for Haywood, Lake and Obion, and Shelby Counties, Tennessee*

[Gianessi and Pugger, Resources for the Future, written commun., 1988]

Pesticide	Application rate (pounds per acre)	Treated acres		
		Haywood County	Lake and Obion Counties	Shelby County
Metalochlor	1.7	6,821	5,768	5,658
Trifluralin	.75	66,612	35,045	36,135
Cyanazine	1.5	4,020	181	1,290
Alachlor	1.5	27,449	22,177	20,766
Atrazine	1.2	6,554	3,060	4,211
Methyl Parathion	.7	4,667	4,146	3,451

Table 4.—*Herbicides applied during April and May 1988, in Haywood, Lake and Obion, and Shelby Counties*

[Sources: William Daniels, Farm Manager, Agricenter International; Calvin Prince, Farm Manager, Shelby County Penal Farm; R. Ward, Farmer; W. Eubanks, Farmer, oral commun., 1988]

Trade name	Chemical Name
Prowl	Pendimethalin
Cotoran	Fluometuron
MSMA	Methylarsonate
Fusilade	Fluazifopp-butyl
Treflan	Trifluralin
Dual	Meatalochlor

properties. One well (Ob:R-002) was located just across the Lake County line in Obion County, and is therefore included with the Lake County wells. This well was sampled in February, but was destroyed prior to the summer sampling period. Well depths range from 17 to 90 feet below land surface (table 5), and all wells are screened in the water-table aquifer.

Two sampling periods were scheduled to bracket the growing season and to determine any effects on ground-water quality with respect to fertilizer and pesticide application. The first set of samples was collected during January and February 1988, when the land was fallow. Samples were collected again in June 1988 directly following application of fertilizer and pesticides which took place in all three areas throughout May (William Daniels, Agricenter International, oral commun., 1988; Calvin Prince, Shelby County Penal Farm, oral commun., 1988; R. Ward, farmer, oral commun., 1988; W. Eubanks, farmer, oral commun., 1988). Applied pesticides are summarized in table 4. During both sampling events, most samples were analyzed for triazine herbicides and all wells were sampled for analyses of the following nitrogen constituents: nitrite plus nitrate, ammonia plus organic nitrogen, and ammonia. Three wells in Shelby County could not be sampled for pesticides in January 1988 because of difficulties collecting a representative sample. Samples collected in Haywood County

Table 5. — *Wells sampled in Haywood, Lake and Obion, and Shelby Counties*

Well Number	Latitude	Longitude	Depth (feet, below land surface)
HAYWOOD COUNTY			
Ha:H-002	353706	0891255	50
Ha:L-002	354319	0891947	30
Ha:L-003	354133	0892127	60
Ha:L-004	353855	0891903	90
Ha:L-005	353756	0891907	90
Ha:M-004	354449	0891334	60
Ha:M-005	354451	0891337	22
LAKE AND OBION COUNTIES			
Lk:E-022	362156	0892610	17
Lk:E-023	362227	0892609	28
Lk:F-001	362503	0892914	40
Lk:G-030	362709	0892415	29
Lk:H-005	362444	0892507	49
Lk:H-003	362924	0892156	29
Ob:R-002	363017	0891653	28
SHELBY COUNTY			
Sh:Q-101	350741	0894909	38
Sh:Q-108	350836	0895032	44
Sh:Q-111	350838	0895113	43
Sh:Q-114	350753	0894933	45
Sh:Q-115	350745	0894945	54
Sh:Q-116	350745	0895140	28

were analyzed also for organophosphorus insecticides.

In order to ensure that representative samples were collected from each well, at least five casing volumes of water were evacuated prior to sampling. The wells at the Agricenter International and the Shelby County Penal Farm were sampled with a stainless-steel bailer. Some of the wells near Reelfoot Lake were sampled with a bailer while others were sampled with a peristaltic pump. The domestic wells in Haywood County were sampled at hydrants or faucets on pressure systems. At these wells, pressure tanks were flushed until specific conductance stabilized to ensure a representative sample.

Water samples were analyzed by the U.S. Geological Survey National Water-Quality Laboratory in Denver, Colorado. Analyses for total nitrite plus nitrate (as nitrogen) were performed on all samples using the cadmium-reduction method (Skougstad and others, 1979). Also, all the water samples were analyzed for total recoverable triazine herbicides using an acid extraction followed by gas chromatography (Wershaw and others, 1983). The samples from Haywood County were also analyzed for total recoverable organophosphorus compounds, using hexane extraction and gas chromatography (Wershaw and others, 1983).

Ground-water levels were measured where possible. No water levels were measured in Haywood County. Water-level data for the two sampling periods are summarized in table 6.

OCCURRENCE OF AGRICULTURAL CHEMICALS IN GROUND WATER

Pesticides

The results of analyses of samples for some of the more commonly used pesticides are presented in table 7. Concentrations of pesticides were below analytical detection limits, which were 0.10 microgram per liter (μg/L) for triazine herbicides, except for one analysis (Sh:Q-114) where the detection limit was 0.20 μg/L, and 0.01 ug/L for organophosphorus insecticides. Triazine herbicides were the only herbicides analyzed for because these are the herbicides most commonly applied to crops grown in West Tennessee. Because of the limited scope of this

Table 6.—*Water levels in wells in Haywood, Lake and Obion, and Shelby Counties, winter and summer, 1988*

[--, water level not measured]

Well number	Water levels (feet below land surface) Winter (January-February) 1988	Summer (June) 1988
HAYWOOD COUNTY		
Ha:H-002	--	--
Ha:L-002	--	--
Ha:L-003	--	--
Ha:L-004	--	--
Ha:L-005	--	--
Ha:M-004	--	--
Ha:M-005	--	--
LAKE AND OBION COUNTIES		
Lk:E-022	8.9	10.6
Lk:E-023	11.4	10.9
Lk:F-001	19.3	21.6
Lk:G-030	5.7	5.1
Lk:H-005	3.5	5.4
Lk:H-003	6.1	8.6
Ob:R-002	--	--
SHELBY COUNTY		
Sh:Q-101	25.9	34.4
Sh:Q-108		39.8
Sh:Q-111	35.5	35.8
Sh:Q-114		43.2
Sh:Q-115	17.1	36.8
Sh:Q-116	12.4	16.8

project, the analyses did not include all of the pesticides applied in the three study areas.

Nitrogen Species

The results of analyses for nitrogen species (table 8) are more variable than the results of pesticide analyses. All 19 wells included in this study were sampled in both winter and summer for nitrite plus nitrate, ammonia plus organic nitrogen, and ammonia. A value for total nitrogen was then calculated from these constituents (table 8). These data are shown graphically in the histograms presented in figures 5, 6, and 7. Summary statistics by county and season for each nitrogen constituent measured are presented in figures 8, 9 and 10. All "less than" values were assigned a value half way between the detection limit and zero for the purpose of these calculations.

Nitrite Plus Nitrate

Nitrite plus nitrate is the most soluble and mobile form of nitrogen in the ground water. Concentrations of nitrite plus nitrate (as nitrogen), in the nineteen wells sampled, ranged from less than 0.1 mg/L (the analytical detection limit) to 7.0 mg/L in January and February, and from less than 0.1 to 8.9 mg/L in June (table 8). Concentrations of nitrite plus nitrate (as nitrogen) in all of the samples analyzed were less than the maximum contaminant level of 10 mg/L as nitrogen established for drinking water (Tennessee Department of Health and Environment, 1988).

In Haywood County, where the shallow water-table aquifer consists of fine-grained silty sands and clay, the concentrations of nitrite plus nitrate were as high as 7.0 mg/L in January, and 8.9 mg/L in June (table 8, figs. 5, 8). The wells in this area are active domestic wells, and are pumped almost continuously. Well depths range

Table 7.—*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples*

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date Sampled	Triazine herbicides					
		Propazine	Trifluralin	Simetryne	Simazime	Prometone	Prometryne
		HAYWOOD COUNTY					
Ha:H-002	04-20-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ha:H-002	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-002	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-003	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-003	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-004	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-004	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-005	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-005	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-004	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-004	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-005	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-005	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
		LAKE AND OBION COUNTIES					
Lk:E-022	02-25-88	--	--	--	--	--	--
Lk:E-022	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:E-023	02-25-88	--	--	--	--	--	--
Lk:E-023	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:F-001	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:F-001	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:G-030	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
LK:G-030	02-25-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-003	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-003	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-005	02-25-88	< .1	< .	--	--	--	--
Lk:H-005	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Ob:R-002	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1

Table 7.—*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples*—Continued

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date sampled	Triazine herbicides					
		Propazine	Trifluralin	Simetryne	Simazime	Prometone	Prometryne
				SHELBY COUNTY			
Sh:Q-101	02-09-88	--	--	--	--	--	--
Sh:Q-101	06-13-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sh:Q-108	02-09-88	--	--	--	--	--	--
Sh:Q-108	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-111	02-09-88	--	--	--	--	--	--
Sh:Q-111	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-114	02-09-88	< .2	< .2	< .2	< .2	< .2	< .2
Sh:Q-114	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-115	02-09-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-115	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-116	02-09-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-116	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1

Table 7.—*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples*—Continued

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date sampled	Triazine herbicides					
		Atrazine	Alachlor	Cyanzine	Ametryne	Metribuzin	Metolachlor
				HAYWOOD COUNTY			
Ha:H-002	04-20-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ha:H-002	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-002	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-003	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-003	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-004	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-004	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-005	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:L-005	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-004	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-004	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-005	04-20-88	< .1	< .1	< .1	< .1	< .1	< .1
Ha:M-005	06-16-88	< .1	< .1	< .1	< .1	< .1	< .1
				LAKE AND OBION COUNTIES			
Lk:E-022	02-25-88	--	--	--	--	--	--
Lk:E-022	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:E-023	02-25-88	--	--	--	--	--	--
Lk:E-023	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:F-001	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:F-001	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:G-030	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
LK:G-030	02-25-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-003	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-003	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Lk:H-005	02-25-88	--	--	--	--	--	--
Lk:H-005	06-15-88	< .1	< .1	< .1	< .1	< .1	< .1
Ob:R-002	02-24-88	< .1	< .1	< .1	< .1	< .1	< .1

Table 7.—*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples*—Continued

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date sampled	Triazine herbicides					
		Atrazine	Alachlor	Cyanzine	Ametryne	Metribuzin	Metolachlor
				SHELBY COUNTY			
Sh:Q-101	02-09-88	--	--	--	--	--	--
Sh:Q-101	06-13-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sh:Q-108	02-09-88	--	--	--	--	--	--
Sh:Q-108	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-111	02-09-88	--	--	--	--	--	--
Sh:Q-111	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-114	02-09-88	< .2	< .2	< .2	< .2	< .2	< .2
Sh:Q-114	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-115	02-09-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-115	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-116	02-09-88	< .1	< .1	< .1	< .1	< .1	< .1
Sh:Q-116	06-13-88	< .1	< .1	< .1	< .1	< .1	< .1

Table 7.—*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples*—Continued

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date sampled	Organophosphorus insecticides					
		Malathion	Parathion	Diazinon	Methylparathion	Trithion	Methyl Trithion
		HAYWOOD COUNTY					
Ha:H-002	04-20-88	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ha:H-002	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-002	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-003	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-003	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-004	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-004	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-005	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:L-005	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:M-004	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:M-004	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:M-005	04-20-88	< .01	< .01	< .01	< .01	< .01	< .01
Ha:M-005	06-16-88	< .01	< .01	< .01	< .01	< .01	< .01
		LAKE AND OBION COUNTIES					
Lk:E-022	02-25-88	--	--	--	--	--	--
Lk:E-022	06-15-88	--	--	--	--	--	--
Lk:E-023	02-25-88	--	--	--	--	--	--
Lk:E-023	06-15-88	--	--	--	--	--	--
Lk:F-001	02-24-88	--	--	--	--	--	--
Lk:F-001	06-15-88	--	--	--	--	--	--
Lk:G-030	06-15-88	--	--	--	--	--	--
LK:G-030	02-25-88	--	--	--	--	--	--
Lk:H-003	02-24-88	--	--	--	--	--	--
Lk:H-003	06-15-88	--	--	--	--	--	--
Lk:H-005	02-25-88	--	--	--	--	--	--
Lk:H-005	06-15-88	--	--	--	--	--	--
Ob:R-002	02-24-88	--	--	--	--	--	--

Table 7. —*Concentrations of triazine herbicides and organophosphorus insecticides in ground-water samples* —Continued

[Total recoverable concentrations in micrograms per liter; --, not sampled; <, less than]

Well number	Date sampled	Organophosphorus insecticides					
		Malathion	Parathion	Diazinon	Methylparathion	Trithion	Methyl Trithion
				SHELBY COUNTY			
Sh:Q-101	02-09-88	--	--	--	--	--	--
Sh:Q-101	06-13-88	--	--	--	--	--	--
Sh:Q-108	02-09-88	--	--	--	--	--	--
Sh:Q-108	06-13-88	--	--	--	--	--	--
Sh:Q-111	02-09-88	--	--	--	--	--	--
Sh:Q-111	06-13-88	--	--	--	--	--	--
Sh:Q-114	02-09-88	--	--	--	--	--	--
Sh:Q-114	06-13-88	--	--	--	--	--	--
Sh:Q-115	02-09-88	--	--	--	--	--	--
Sh:Q-115	06-13-88	--	--	--	--	--	--
Sh:Q-116	02-09-88	--	--	--	--	--	--
Sh:Q-116	06-13-88	--	--	--	--	--	--

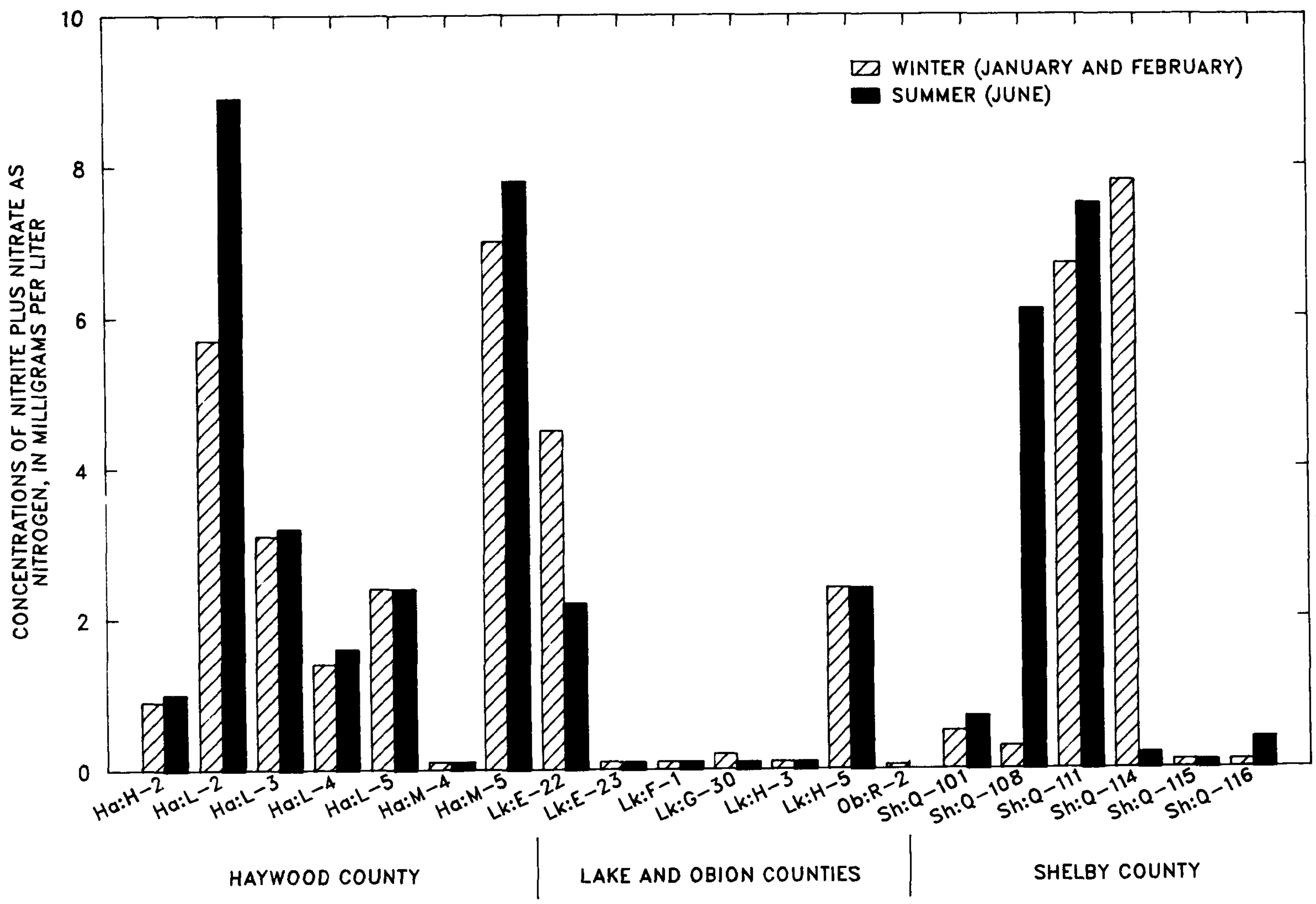

Figure 5.--Concentrations of nitrite plus nitrate as nitrogen in water from wells in three sampling areas, winter and summer, 1988.

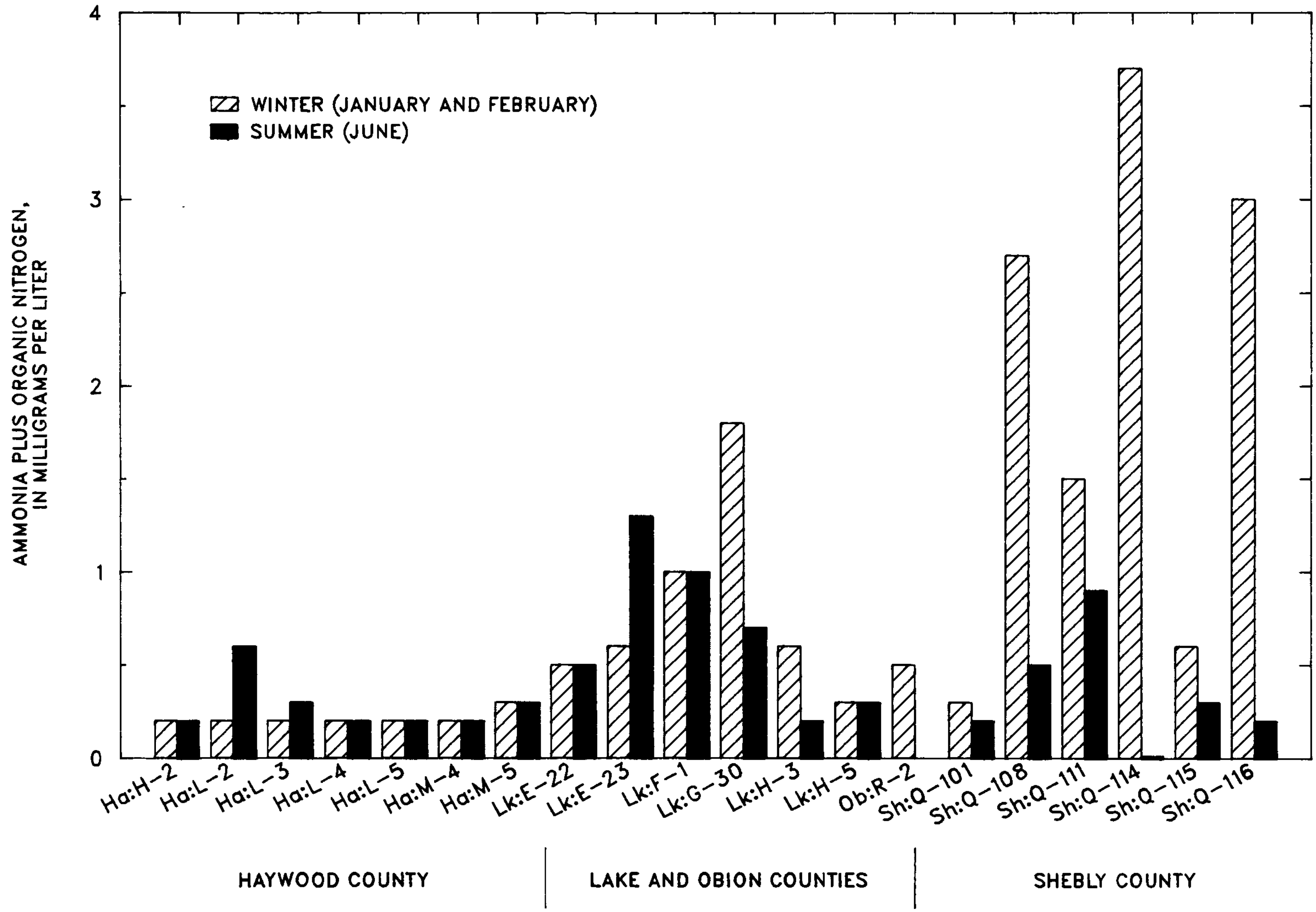

Figure 6.--Concentrations of ammonia plus organic nitrogen in water from wells in three sampling areas, winter and summer, 1988.

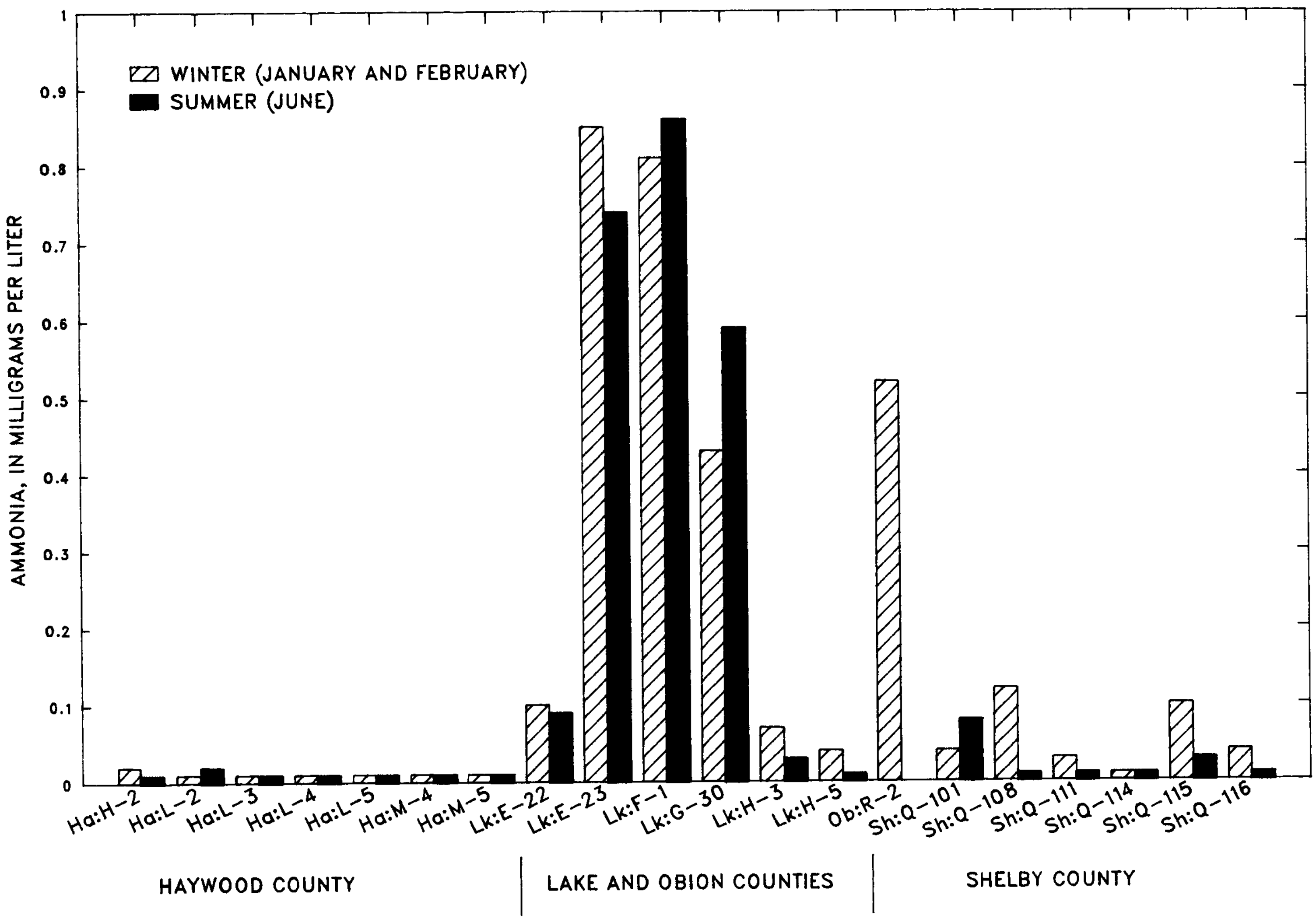

Figure 7.--Concentrations of ammonia in water from wells in three sampling areas, winter and summer, 1988.

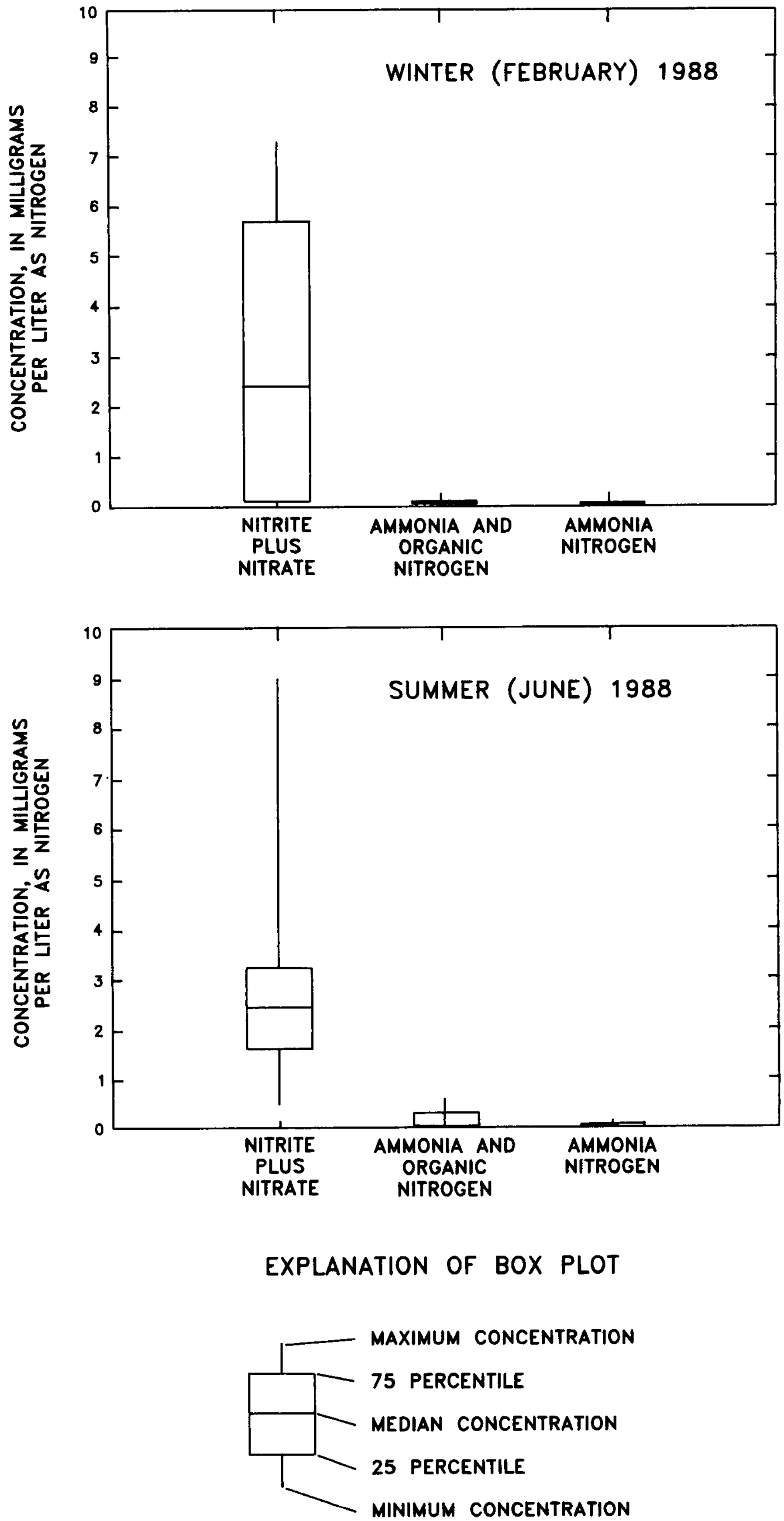

Figure 8.--Summary of analytical results for nitrogen constituents in ground water in Haywood County, winter and summer, 1988.

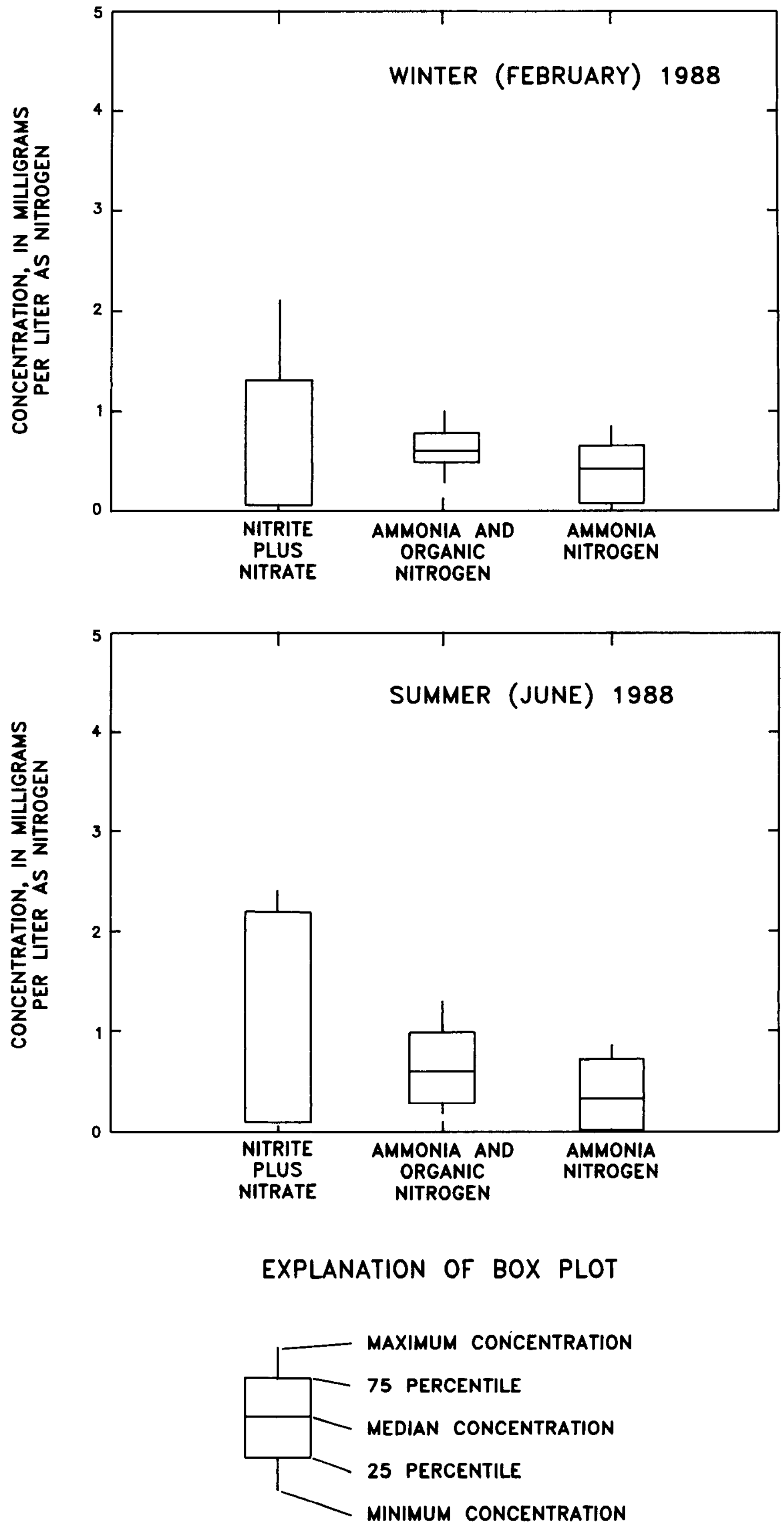

Figure 9.--Summary of analytical results for nitrogen constituents in ground water in Lake and Obion Counties, winter and summer, 1988.

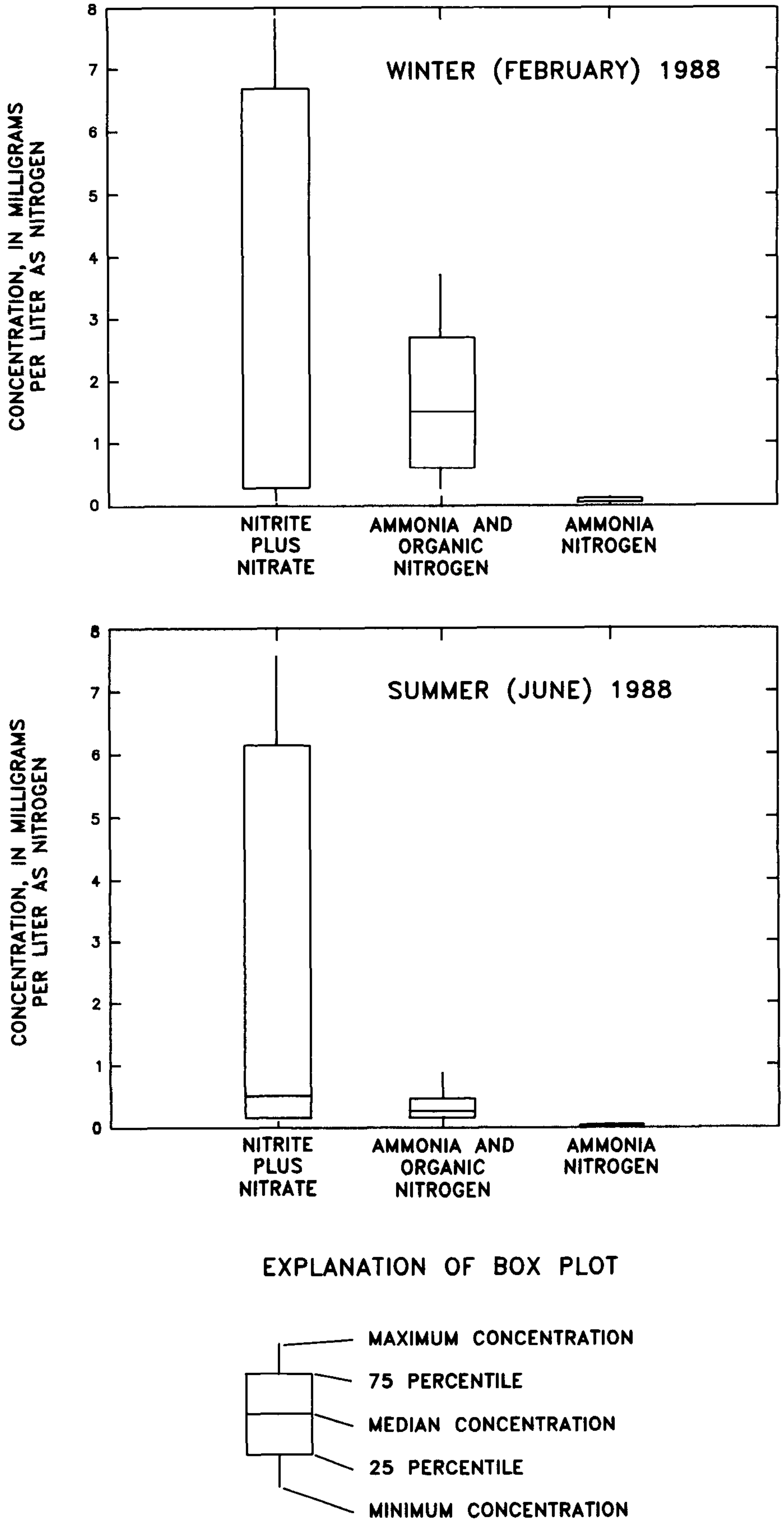

Figure 10.--Summary of analytical results for nitrogen constituents in ground water in Shelby County, winter and summer, 1988.

Table 8. —*Concentrations of nitrogen constituents in ground water from wells in Haywood, Lake and Obion, and Shelby Counties*

[Concentrations reported in milligrams per liter as nitrogen; --, not sampled; <, less than]

Well number	Date sampled	Ammonia	Ammonia plus Organic	Nitrate plus nitrite
		HAYWOOD COUNTY		
Ha:H-002	01-26-88	0.02	<0.20	0.9
Ha:H-002	06-16-88	<.01	<.20	1.0
Ha:L-002	01-26-88	<.01	<.20	5.7
Ha:L-002	06-16-88	<.02	.60	8.9
Ha:L-003	01-26-88	<.01	<.20	3.1
Ha:L-003	06-16-88	<.01	.30	3.2
Ha:L-004	01-26-88	.01	<.20	1.4
Ha:L-004	06-16-88	<.01	<.20	1.6
Ha:L-005	01-26-88	<.01	.20	2.4
Ha:L-005	06-16-88	<.01	.20	2.4
Ha:M-004	01-26-88	<.01	<.20	<.1
Ha:M-004	06-16-88	<.01	<.20	<.1
Ha:M-005	01-26-88	<.01	.30	7.0
Ha:M-005	06-16-88	<.01	.30	7.3
		LAKE AND OBION COUNTIES		
Lk:E-022	02-25-88	.10	.50	4.5
Lk:E-022	06-15-88	.09	.50	2.2
Lk:E-023	02-25-88	.85	.60	<.1
Lk:E-023	06-15-88	.74	1.3	<.1
Lk:F-001	02-24-88	.81	1.0	<.1
Lk:F-001	06-15-88	.86	1.0	<.1
Lk:G-030	02-25-88	.43	1.8	.2
Lk:G-030	06-15-88	.59	.70	<.1
Lk:H-003	02-24-88	.04	.30	2.4
Lk:H-003	06-15-88	<.01	.30	2.4
Lk:H-005	02-25-88	.07	.60	<.1
Lk:H-005	06-15-88	.03	<.20	<.1
Ob:R-002	02-24-88	.52	.50	<.1

Table 8.—*Concentrations of nitrogen constituents in ground water from wells in Haywood, Lake and Obion, and Shelby Counties*

[Concentrations reported in milligrams per liter as nitrogen; --, not sampled; <, less than]

Well number	Date sampled	Ammonia	Ammonia plus Organic	Nitrate plus nitrite
		SHELBY COUNTY		
Sh:Q-101	02-09-88	0.04	0.30	0.5
Sh:Q-101	06-13-88	.08	<.20	.7
Sh:Q-108	02-09-88	.12	2.7	.3
Sh:Q-108	06-13-88	<.01	.50	6.1
Sh:Q-111	02-09-88	.03	1.5	6.7
Sh:Q-111	06-14-88	<.01	.90	7.5
Sh:Q-114	02-09-88	<.01	3.7	7.8
Sh:Q-114	06-13-88	--	--	.2
Sh:Q-115	02-09-88	.10	.60	<.1
Sh:Q-115	06-14-88	.03	.30	<.1
Sh:Q-116	02-09-88	.04	3.0	<.1
Sh:Q-116	06-14-88	<.01	<.20	.4

from 22 to 90 feet below land surface (table 5). The highest concentrations, measured during both the winter and summer sampling efforts, were in samples from the two shallowest wells. One well, Ha:L-002, is 30 feet deep and is located on the edge of a field that was heavily irrigated during 1988. Nitrite plus nitrate concentrations for this well were 5.7 mg/L in January 1988 and 8.9 mg/L in June 1988. The second well, Ha:M-005, is 22 feet deep. Nitrite plus nitrate concentrations for this well were 7.0 mg/L in January and 7.3 mg/L in June.

Concentrations of nitrite plus nitrate in wells sampled in Lake and Obion Counties ranged from less than 0.1 to 4.5 mg/L in February, and from less than 0.1 to 2.4 mg/L in June. The wells are abandoned domestic wells, except Lk:G-030, which was installed for water-level data collection for another project of the USGS. Well depths range from 17 to 49 feet below land surface (table 5). For February analyses, the median nitrite plus nitrate concentrations in these wells was 1.1 mg/L, and the mean was 1.2 mg/L. For June analyses, the median nitrite plus nitrate concentrations was 0.8 mg/L; the mean, less than the analytical detection limit (table 8, figs. 5, 9). For purposes of computing means, values reported as less than 0.1 mg/L (the detection limit) were assigned values of 0.05 mg/L.

Concentrations of nitrite plus nitrate, measured in samples from wells in Shelby County, ranged from less than 0.1 to 7.8 mg/L in samples collected in February, and from less than 0.1 to 7.5 mg/L in samples collected in June. Well depths range from 28 to 59 feet below land surface. For February samples, the median concentration was 0.4 mg/L and the mean, 2.6 mg/L. For June samples, the median was 0.6 mg/L, the mean, 2.5 mg/L (table 8, figs. 5, 10). In one well, Sh:Q-108, the concentration of nitrite plus nitrate increased from 0.3 to 6.1 mg/L from February to June, while in well Sh:Q-114, the concentration decreased from 7.8 to 0.2 mg/L during that period.

Because of the limited scope of this investigation, information on actual rates of fertilizer application in the study areas was not obtained. Analyses were made for nitrate constituents, because, historically, nitrate fertilizers are the most commonly used fertilizer in West Tennessee. However, potential differences among the three areas between fertilizer application rates and crop types cannot be determined from this study.

Ammonia Plus Organic Nitrogen

High concentrations of ammonia plus organic nitrogen are indicative of a reducing environment, and are more commonly associated with decaying organic matter. In instances where concentrations of ammonia plus organic nitrogen are high, concentrations of nitrite and nitrate, which are commonly associated with oxidizing environments, are usually low.

In Haywood County, the concentrations of ammonia plus organic nitrogen in samples collected in January ranged from less than the analytical detection limit of 0.20 to 0.30 mg/L. The median was 0.05 and the mean was 0.2 (table 8, figs. 6, 8). The concentrations of ammonia plus organic nitrogen from June analyses ranged from the analytical detection limit to 0.60 mg/L. The mean and the median concentrations were calculated to be at or below the detection limit for samples collected in January and June 1988.

In Lake and Obion Counties, the concentrations of ammonia plus organic nitrogen in water from the six wells sampled ranged from 0.3 to 1.8 mg/L in February, and from less than 0.20 to 1.3 mg/L in June (table 8, figs. 6, 9). The mean concentration in February was 0.8 mg/L, while the median was 0.6 (fig. 9). For samples collected in June, the mean and median concentrations were 0.6 mg/L.

Concentrations of ammonia plus organic nitrogen for samples collected in Shelby County during February ranged from 0.30 to 3.7 mg/L. The median concentration was 2.1 mg/L and the mean, 2.0 mg/L (table 8, figs. 6, 10). In June, the concentrations ranged from less than 0.20 to 0.9 mg/L. The median concentration was 0.2 mg/L and the mean, 0.3 mg/L. The concentrations of ammonia plus organic nitrogen generally were higher in samples collected during February than in those collected in June.

Ammonia

Ammonia is one of the principal forms of nitrogen applied to crops in the study area as fertilizer. Under oxidizing conditions, ammonia is converted to nitrate (nitrification).

For Haywood County, the concentrations of ammonia as nitrogen in samples collected in January and June were mostly below the analytical detection limit of 0.01 mg/L (figs. 7, 8, table 8). The concentrations of ammonia generally were higher in Lake and Obion Counties than in the other areas for samples collected in winter and summer. In these counties, concentrations measured in February ranged from 0.07 to 0.9 mg/L; and in June, from less than 0.01 to 0.9 mg/L. In Shelby County, concentrations of ammonia ranged from less than 0.01 to 0.1 mg/L in February and from less than 0.01 to 0.08 mg/L in June.

The elevated concentrations of ammonia (and ammonia plus organic) nitrogen measured in the February samples from Shelby County may be the result of sampling procedures. In

February, these wells were purged and sampled with a bailer, but in the summer, a submersible pump was used to purge the wells. Also, the elevated concentrations of ammonia found in both of the sample sets for Lake and Obion Counties could be due to the fact that these wells were purged and sampled using a peristaltic pump. It is also possible that the differences in concentrations of ammonia (and ammonia plus organic) nitrogen between areas could be due to differences in agricultural practices.

SEASONAL VARIATION IN CONCENTRATIONS OF AGRICULTURAL CHEMICALS

In order to determine the variability between winter and summer sample sets, a standard statistical method was applied. This method, the Sign Test, is a nonparametric test which is based on the signs of the response differences (Bhattacharyya and Johnson, 1977). From this test, any variability can be seen in the acceptance or rejection of the null hypothesis (H_0) that concentration in samples from both seasons are not significantly different. This hypothesis was tested for total nitrite plus nitrate nitrogen, ammonia plus organic nitrogen, and ammonia nitrogen data. For nitrite plus nitrate, H_0 was accepted with a level of significance (α) of 0.033. For both ammonia plus organic nitrogen and ammonia nitrogen, the null hypothesis was rejected at levels of significance of 0.033 and 0.029, respectively. These results indicate that there is no statistically significant difference between the two sample populations for total nitrite plus nitrate, although there are statistically significant differences in the concentrations of ammonia plus organic nitrogen and ammonia nitrogen between the data sets for the two seasons.

SUMMARY AND CONCLUSIONS

Increased agricultural production in West Tennessee has been accompanied by a greater use of fertilizers and pesticides, and the potential effect of these chemicals on ground-water quality is of growing concern. Irrigation, which also has increased in recent years, can increase the potential for ground-water contamination by leaching the fertilizers and pesticides into the ground-water system. Shallow ground water is the source of drinking water for many rural families.

To investigate the potential ground-water-quality problems in agricultural areas of West Tennessee, the U.S. Geological Survey in cooperation with the Tennessee Department of Health and Environment conducted a reconnaissance study of ground-water quality in 1988. Nineteen wells were sampled in three agricultural areas in West Tennessee. All wells were completed in the shallow ground-water system, with depths ranging from 17 to 90 feet below land surface. The wells were sampled during winter and spring to define seasonal variations in ground-water quality that might be related to fertilizer and pesticide application.

The highest concentrations of nitrite plus nitrate were measured in wells that range in depth from 22 to 45 feet below land surface. The water sample having the highest nitrite plus nitrate concentration came from a well located close to an irrigation system. Nitrite plus nitrate concentrations in samples from the 19 wells sampled ranged from less that 0.1 to 8.9 mg/L. Concentrations in all of the wells sampled were less than the maximum contaminant level of 10 mg/L established for drinking water.

Concentrations of ammonia plus organic nitrogen ranged from 0.2 to 3.7 mg/L and generally were higher in samples collected in January and February than in samples collected in June. Concentrations of ammonia nitrogen ranged from less than 0.01 to 0.9 mg/L and also tended to be higher in samples collected during winter months. However, the higher concentrations measured in the winter samples may have been the result of differences in sampling procedures.

No pesticides were detected in the ground-water samples collected as part of this study. This indicates that the pesticides applied to the fields had not reached the saturated zone of the aquifer. However, the areal coverage of the sampling effort may not have been adequate to document localized occurrence of pesticides in ground water and the analyses did not include all of the pesticides used in the area. Also, 1988 was a year of record drought conditions and the paucity of rain may have delayed the movement of pesticides applied to the land surface into the shallow ground water. It is also possible that the pesticides could have biodegraded into daughter compounds that were not detected.

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